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ABSTRACT

This Science Study Aid (SSA), structured for grade levels 7-9, is based on work of the U.S. Department of Agriculture's Agricultural Research Service (ARS) conducted at the Western Regional Research Center in Berkeley, California. It is concerned with food aroma, its intensity and character, and olfactory threshold determinations. The SSA provides students with background information to help understand the importance of determining odor preferences and olfactory thresholds. There are three investigations for the student entitled: Fruit Flies and Bananas, Preference Testing, and Olfactory Threshold Determination. In the section entitled To the Teacher, suggestions are provided for each of the investigations to facilitate classroom use. Included are: Materials Lists, Directions for Preparing Solutions, and Suggested Readings and Films. (BT)

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Exploring Your Sense of Smell

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Science Study Aid SERIES

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Exploring Your Sense of Smell

Developed by **John Boeschen**, *a secondary science teacher in Pinole, Calif. Mr. Boeschen prepared the manuscript in cooperation with* **Dr. John E. Amoore** *and* **Mr. Dante G. Guadagni**, *scientists of the Agricultural Research Service, U.S. Department of Agriculture, at the Western Regional Research Center, Berkeley, Calif.*

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TO THE TEACHER

This Science Study Aid (SSA) is based upon work of the U.S. Department of Agriculture's Agricultural Research Service (ARS) conducted at the Western Regional Research Center in Berkeley, Calif. It is concerned with food aroma, its intensity and character, and olfactory threshold determinations (the lowest concentration of a substance that can be repeatedly distinguished from water by its odor). The SSA provides students with background information to help understand the importance of determining odor preferences and olfactory thresholds. There are three Investigations for the student. In this section, entitled To the Teacher, suggestions are provided for each of the Investigations to facilitate classroom use.

Exploring Your Sense of Smell is structured for grade levels 7-9. It is designed to stimulate creative thinking and to act as a focal point for class or group discussion. The Investigations acquaint students with scientific procedure and are geared to reinforce basic mathematical concepts. This SSA is an appropriate supplement to general science courses. Also, it is readily adaptable to vocational education and social science (consumer economics) classes.

In the section, To the Student, following, students are introduced to the concept of primary odors and "odor-blindness" (*anosmia*). Here, we have explained to students that ARS scientist Dr. John E. Amoore first suspected the existence of what he called primary odors when he realized that there were people who could not smell (were anosmic to) certain odors. As of 1974 he suspected the existence of 27 such odors.

Because of the increased use of synthetic food products such as whipped desserts, sauce mixes, and instant breakfast drinks, the need to identify these odors has become increasingly important. Flavorants must be added to make

MATERIALS LISTS

For your convenience, we have listed below the materials needed to perform all the Investigations contained in this Science Study Aid. The following list gives the quantities needed for each team of four students:

STUDENT MATERIALS

- 10 *Drosophila* (fruit flies)
- 1 fermenting banana
- 1 wide-mouthed gallon jar with lid (or aquarium)
- 2 baby-food sized jars with lids
- opaque paper (to cover one small jar)
- 2 narrow-mouthed polyethylene bottles (250 ml) with plastic caps
- 2 plastic straws
- odorous food substances (water soluble) for test solutions
- 2 to 3% TSP (trisodium phosphate) solution
- vacant table or desk to be used as an Odor Research Bar for testing

TEACHER MATERIALS

- yeast

OPTIONAL

- putrescine (see page 4)
- buffer solution of borax (sodium tetraborate —$Na_2B_4O_7 \cdot 10H_2O$)
- distilled water
- Bunsen burner
- containers for solutions

bland synthetic foods more palatable. Correct identification and chemical analysis of the primary odors help ARS researchers in their efforts to discover effective and safe (non-toxic) chemicals for flavoring.

As suggested in the section To the Student, a solution of the primary odor 1-pyrroline can be prepared to help separate the nonsmellers from the smellers in your class. In this country, 17 percent of the population is anosmic to this chemical. Your students may find it interesting to discover what percentage of their class is "odor-blind" to 1-pyrroline. We have not included this test in the following investigations, but have presented the "recipe" below in case your students wish to investigate.

PREPARING 1-PYRROLINE

1-Pyrroline is not available commercially. However, its odor usually is present in putrescine as an impurity.

1. Prepare a buffer solution of borax (sodium tetraborate—$Na_2B_4O_7 \cdot 10H_2O$). Place 38 grams of the chemical in 1 liter of distilled water. Warm the putrescine to at least 27°C to melt it. Then add ½ cc of the melted putrescine to 500 ml of the buffer solution.

2. Put the putrescine solution in one bottle and an equal amount of the buffer solution in another. Ask students to identify the bottle with the odor (see Figure 2).

Putrescine can be obtained from the Aldrich Chemical Company at the following addresses:

10 Ridgedale Avenue
P.O. Box AA
Cedar Knolls, N. J. 07927

90 West Saint Paul Avenue
Milwaukee, Wisc. 53233

2098 Pike Street
P.O. Box 1814
San Leandro, Calif. 94577

RAISING FRUIT FLIES FOR INVESTIGATION 1

Drosophila melanogaster (fruit flies) are attracted by, and found in abundance in soft, aromatic fruits such as grapes, bananas, and plums, especially if they are overripe and have begun to ferment. Adult flies as well as their larvae feed on fruit juices; and, since yeast is present wherever fermentation is in progress, it is believed that yeast constitutes an important part of the *Drosophila* diet. Consequently, *Drosophila* may be raised on any fermenting medium.

A simple method to develop a colony of *Drosophila* is to dip a piece of well-ripened banana (peeled), 1½ to 2½ inches long, into a 2 to 3 percent suspension of yeast in water. Then put the banana in a small glass container such as a shell vial, one-pint milk bottle, or a small mayonnaise jar. Narrow-mouth containers hold the banana food in place better than wide bottles.

Place the jar in a warm location—the window sill in your kitchen, outside near trash containers, or in your school's kitchen area. In 2 to 7 days the *Drosophila* colony should reach a population sufficient for the Investigation. Trap the flies in the container by closing it with a cotton plug or other suitable cover until you are ready to use them. Flies thrive for several weeks in cultures prepared in this way, provided good culture conditions are maintained.

In the Investigation the students will

be doing, the *Drosophila* are drawn to the fermenting banana because of its odor. The senses of sight, sound, and touch play no significant role in attracting them. Be sure the banana does not come in contact with the outside of the small jar or with the inside of the gallon jar (see Figure 1). Such contamination may lead the flies away from the original banana. Place the banana inside the large jar just prior to releasing the fruit flies.

SETTING UP AN ODOR RESEARCH BAR FOR INVESTIGATIONS 2 AND 3

These Investigations require that the class be divided into research teams. The area in which each team performs its Investigation is called an Odor Research Bar. In setting up the Odor Research Bars, attention should be paid to team structure. We would suggest that each research team consist of four members. When the class is conducting its preference tests, team-member jobs might be outlined as shown following. You may wish to duplicate or copy these student jobs and activities and pass them out to the team members, or place them on a handy bulletin board for the entire class.

In both Investigations 2 and 3, the contents of the bottles should be revealed only after each Investigation has been completed.

Team Jobs for Investigation 2 Preference Testing

Job 1. One team member signs and hands out the questionnaire.

Job 2. A second team member administers the test to see that it is done correctly.

Job 3. The third team member collects the questionnaire and transcribes the data on the team's data sheet.

Job 4. The fourth team member tests the samples at his and the other Odor Research Bars.

When the fourth member returns to his Bar, he assumes Job 1, and everyone else performs the next job in line. The last person on the team now starts his preference testing. The actual testing is over when all members of all teams have completed their choices.

Team Jobs for Investigation 3 Olfactory Determination

In measuring olfactory thresholds, the job assignments essentially are the same with minor deviations:

Job 1. This team member signs his name to the questionnaire brought to him by the student judge.

Job 2. Once again, one member sees that the test is administered properly.

Job 3. The third member checks to see that the form has been filled out correctly, and makes certain the student judge waits at least 30 to 60 seconds before going on to the next Bar.

Job 4. The fourth member of the team, the student judge, goes to all the Odor Research Bars and tests the samples found there.

When the fourth member returns from testing, he assumes Job 1 and everyone assumes and performs the next job in line.

PREPARATION FOR INVESTIGATION 2

Food Acceptability and Odors

Discussion of the results from Investigation 1 eventually will lead students to the question, "Are odors also important to man?" Reasons, pro and con, can be listed on the blackboard and in student notebooks. If you feel the class needs an extra push to get them going, cut a slice of apple and rub a small amount of almond extract on it (any essence will do, as long as it doesn't discolor the apple slice. Other possibilities include orange extract, dilute vanilla extract, or mint sauce—check the spice section of your local supermarket).

Next, ask one of your students of he'd eat it. There'll be some hesitation and eventually a remark to the effect, "It doesn't smell right." Ask the students if their parents would buy a bag of apples that smelled that way. This highlights a major problem that concerns food processors: Food must smell the way the public expects it to smell.

The Odor Research Bar as Testing Panel

One of the methods used to insure the quality of aroma is the testing panel. This is a group of people who aid food processors and researchers in evaluating odor according to such factors as preference and intensity. Their equipment—the human nose. This SSA makes use of such panels and allows the students to determine their own preferences among certain foodstuffs.

In trial runs of *Exploring Your Sense of Smell*, comparisons of canned orange juice/frozen orange juice, grape soda/grape juice, and "organic" apple juice/regular apple juice were made. The number of odorous substances available to use are almost limitless—Tabasco sauce, soy sauce, garlic, sauerkraut juice, fish odors such as cod liver oil and clam juice, curry and other spices and herbs, perfumes, mint sauce, horseradish, peanut butter, and so on! For accurate results, the tests should be run at least two or three times. You should always have the samples prepared before class time. If your class tests another class, the teams may prepare the samples at their Odor Research Bar.

Using the Forms and Charts

Notice that all the forms are designed for four Odor Research Bars. Both blank and examples of completed forms are provided at the end of each Investigation.

Questionnaire Form: On the bottom half of the form are two squares with lines beside them. Before the sheet is handed to the student judge, the numbers of the two samples being tested are to be written on the lines by the member of the team performing Job 1. The judge, in turn, is to place a check mark in the square next to the number of the sample he preferred.

Team Data Chart: The sample numbers are to be put in the boxes on the left side of the chart. When a judge finishes making his preference selections, he hands his sheet to the recorder (Job 3) of that particular Bar. The recorder then marks down the judge's preference on the team data sheet by putting a "B" for every boy vote or a "G" for every girl vote in one of the small boxes next to the preferred sample. After all testing for 1 day is completed, the tallies for boys and girls are totaled individually and then together. This final tally number is entered in the rectangular box after "Boy" or "Girl" totals. Using these data, the class fills

out the Class Data Chart together.

The Class Data Chart: This chart is to display all the data collected, and to reinforce addition, division, and percents (or fractions). The vertical columns labeled "Girl Preferences," "Total Girl Judgments," and "% Girl Preferences" should be treated as one unit. The same is true for the three "Boy" columns. The sum of the two numbers entered under "Girl Preferences" equals the number of "Total Girl Judgments." The formula looks like this:

$$\frac{\text{Girl Preferences}}{\text{Total Girl Judgments}} \times 100 = \% \text{ Girl Preferences}$$

The same procedure is used in tabulating the calculations for "Combined Boy and Girl Preferences per Product," "Boy and Girl Total Judgments," and "Total Preferences."

PREPARATION FOR INVESTIGATION 3

Olfactory threshold is the term used to describe the weakest solution of an odorous substance that can be repeatedly distinguished from plain water. This Investigation is designed to determine the average olfactory threshold of the class for a substance of your choice. The samples used in this Investigation should be those familiar to the students. In one trial class, the students determined their average olfactory threshold for horseradish. The possibilities of choice are almost unlimited.

Preparing the Dilutions

1. Pour 100 ml of the undiluted sample into a testing bottle. The concentration of this sample will be arbitrarily defined as Concentration 1.
2. Pour 100 ml of fresh water into a beaker. To it add 100 ml of the undiluted sample and stir well. Pour 100 ml of this diluted solution into a test bottle. The concentration of this bottle will be ½ of the first bottle, or 0.5. Save the remaining 100 ml of solution for Step 3.
3. Add 100 ml of water to the 100 ml of solution remaining from Step 2 and stir well. Pour 100 ml of this solution into one of the polyethylene test bottles. The concentration of this solution is ½ the second bottle, or 0.25. Save the remaining 100 ml of solution for Step 4.
4. To the 100 ml of solution remaining from Step 3, add 100 ml of fresh water and stir well. Pour 100 ml of this solution into a test bottle. The concentration of this bottle is 0.125. Save the remaining 100 ml if you wish to make further dilutions. If so, proceed as in Step 3 above.

The odor of the last concentration you prepare should be barely detectable, if at all. Your nose will have to be your guide. If you feel all the concentrations are too strong, start over and use a more dilute starting solution, calling it Concentration 1. Halving the other samples in the manner described above will give you the proper serial dilutions.

Each concentration is then placed on an Odor Research Bar where it is paired with a bottle containing only water. The olfactory threshold test should be run at least twice for best results. When everyone has completed sniffing, fill out the class data forms and plot the graphs together.

USING THE FORMS, CHARTS, AND GRAPH

Notice that both blank and completed example forms have been provided at the end of each Investigation.

Questionnaire Charts for Investigation 2: The student judge will take the same questionnaire with him to all the Odor Research Bars. The first member of each team records his Bar number on the sheet when the judge arrives. At the same time, the numbers of the two sample bottles are placed on the questionnaire. After testing the samples, the judge circles the one he believes contains the odor. The recorder (Job 3) checks the sheet for accuracy, then signs his name. After all testing has been completed, the teacher announces the concentration of the sample found at each Odor Research Bar and this is recorded on the questionnaire. Following this, the samples containing the solution are revealed by the teacher and the sheets are scored.

Team Data Charts and Class Graph for Investigation 3: When each team has tallied the number of its correct responses on the questionnaire chart, the team data chart is filled out and the class graph plotted, using the results of all team data charts. Each student should be provided with one team chart and one class graph. The intersection of your class curve with the dotted line on the graph will give you the class average olfactory threshold for the sample tested.

SUGGESTED READING

Molecular Basis of Odor, Amoore, John E., Charles C. Thomas (Publisher), Bannerstone House, Springfield, Ill., 1970.

This is a very technical book and is recommended for teachers who wish to go into greater detail on the stereochemical theory of odor.

"The Stereochemical Theory of Odor," Amoore, John E., Johnston, James W., Jr., and Rubin, Martin; *Scientific American*, February 1964. Available in most libraries. This article deals primarily with the stereochemical theory of odor. It is easy reading and recommended for advanced classes.

Carolina Drosophila Manual, Flagg, Raymond O., Carolina Biological Supply Co., Burlington, N.C., Gladstone, Oreg., 1973. Detailed information on rearing fruit flies.

"Specific Anosmia: A Clue to the Olfactory Code," Amoore, John E., *Nature*, (London), Vol. 214, pp. 1095 to 1098 (June 10, 1967). This article is recommended for teachers who are interested in detailed information relating to anosmia and primary odors. It is not recommended for student reading.

Drosophilia Guide: Introduction to the Genetics and Cytology of Drosophila Melanogaster, Demerec, M., and Kaufmann, B. P., 8th ed., Carnegie Institution of Washington, Washington, D.C., 1972. An in-depth guide to raising fruit flies with step-by-step instructions. Recommended for teacher use only.

SUGGESTED FILMS

"Sense of Smell," *Science in Action* broadcast, 1965. Write to TV Dept., California Academy of Sciences, Golden Gate Park, San Francisco, Calif. 94118. 16 mm color. Excellent film covering stereochemical theory, primary odors, importance to man, and testing procedures. Recommended for all classes.

TO THE STUDENT

You probably hear the word "flavor" many times a day—the creamy flavor of a chocolate milkshake, the nutty flavor of the peanut butter and jelly sandwich you had for lunch, or perhaps the "wide-awake" flavor of your morning orange juice. A number of things influence flavor—taste, odor, color, texture, even your mood. One of the most important of these is odor. An apple that looks good but doesn't smell the way you think an apple should smell probably won't have a good apple flavor.

To discover how important odor is in determining the flavor of food, do the following mini-investigation: Have a friend blindfold you. Then, holding your nose, eat a small slice of apple and then a small slice of radish. Could you tell the difference between the two foods? Was it a big difference? Because odor is important in determining the flavor of a food, food packagers and grocery store managers are careful to insure that their products smell the way people expect them to smell.

Animals, such as your dog or cat, use their sense of smell as a warning device. When a dog or cat leaves his territory, his sense of smell warns him both of seen and unseen dangers. Unlike our pets, we don't rely on our sense of smell as heavily, but there may be times when our safety depends on our ability to smell. For example, if you open a can of fish or meat that has spoiled, a putrid odor may reach your nose early enough to warn you of possible danger to your health.

Many homes in our country are heated by gas. Did you know that refined gas is odorless? Because of this, gas companies add special chemicals, called odorants, to the gas so that it can be easily detected were a leak to occur. However, people differ in the intensity of the odors they can perceive. In fact, just as there are people who are color-blind, there are people who are "odor-blind" (anosmic) to certain smells.

Suppose that an odorant to which 10 out of every 100 people are anosmic is added to a city's gas supply as a safeguard. If a gas leak were to occur, what might happen to those people who could not detect the odor of the gas? Research into our sense of smell has insured that odors detectable by the greatest percentage of the population are used and that instances such as the one just described do not occur.

Dr. John E. Amoore, Research Chemist with the Agricultural Research Service (ARS) of the U.S. Department of Agriculture at the Western Regional Research Center in Berkeley, Calif., is well known for his pioneering research into the sense of smell. At his laboratory in Berkeley, Dr. Amoore is investigating some of the complex factors responsible for the flavor of food. He believes that there are primary odors just as there are primary colors. In 1969 he hypothesized the existence of 27 of these primary odors.

According to Dr. Amoore, primary odors are similar to the primary colors in that all odors can be made from different combinations of these 27 primary odors. By 1974, he had experimentally determined two of the primary odors: the sweat odor of the chemical isovaleric acid and the cornlike odor of 1-pyrroline.

In this country, 17 percent of the population is anosmic to 1-pyrroline. You may wish to ask your teacher to prepare a solution of the primary odor 1-pyrroline, which will enable you to separate the "odor-blind" from the "non-odor-blind" students in your class. You can then calculate what percentage of your class is anosmic and compare it

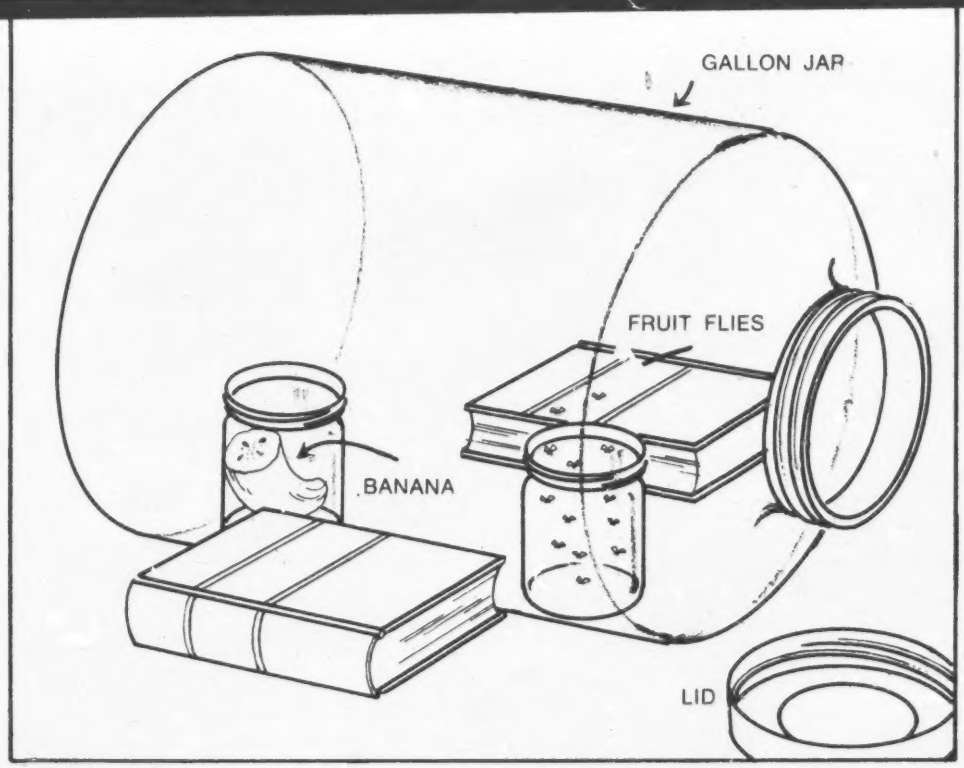


FIGURE 1

with the national average of 17 percent.

Our scientifically oriented world today uses complicated techniques such as gas chromatography to separate and identify the different parts of chemical mixtures, and infra-red and ultra-violet absorption spectroscopy to identify chemicals by the amount of infra-red and ultra-violet light they absorb. However, despite our advanced technology, scientists must depend most heavily on the human nose to help identify the odors of different chemicals. Oddly, people are more accurate than scientific equipment in this kind of research. This is why ARS scientists use testing panels—groups of people and their noses to aid them in their research investigations.

In the following Investigations, you and your classmates will set up testing panels similar to the ones used by ARS scientists. You will then be able to perform research showing which odors are both preferred and most easily detected by people.

INVESTIGATION 1
Fruit Flies and Bananas

Materials (per team)

10 *Drosophila*
1 fermenting banana (peeled)
1 wide-mouthed gallon jar with lid or aquarium
2 small jars (baby-food size) with lids
opaque paper (enough to cover one of the small jars)

PROCEDURE

1. Place the fermenting banana in a small, uncovered jar. Put this jar inside and at the far end of the gallon container laid on its side or in an aquarium (see Figure 1).
2. Place the small covered jar containing the fruit fly culture just inside the opening of the gallon jar. Then remove its covering. Next, quickly cover the gallon jar so that the fruit flies cannot escape.

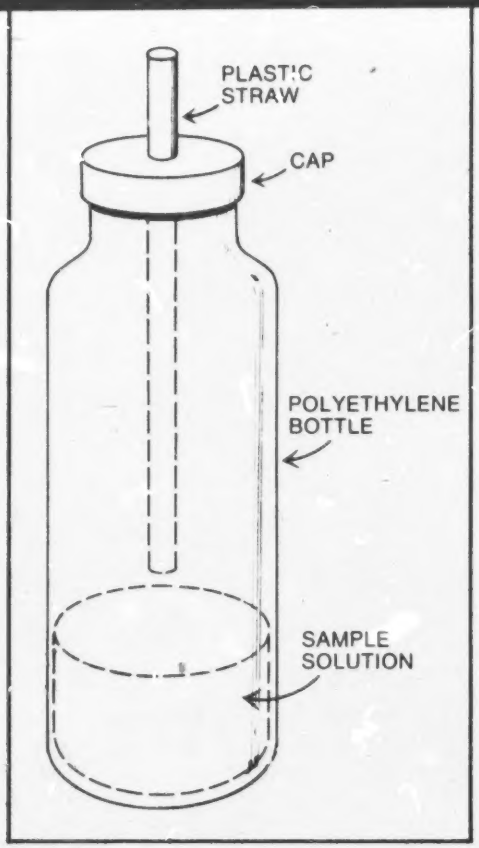


FIGURE 2

3. Observe the fruit flies. Describe their behavior in your notebook.

Questions for Thought

1. Once the fruit flies are released inside the larger container, what do they do?
2. Which of the following senses do the fruit flies use to arrive at their destination?
   sight
   sound
   smell
   touch
3. Can you devise an investigation using the opaque paper to discover if fruit flies can locate the banana without seeing it?

Extending the Investigation

- Set up your own investigation to discover if fruit flies are attracted to other things.
- Go back to your original investigation and see if you can find other organisms that bananas attract.

Suggested Reading

The Science of Smell, Wright, R. H., George Allen & Unwin Ltd., London, 1964. A major portion of this work is devoted to animals and smells. Chapters 3 and 4 deal specifically with fruit flies. Very easy reading.

INVESTIGATION 2
Preference Testing

Materials (per team)

2 narrow-mouth polyethylene bottles (250 ml) with plastic caps
2 plastic straws
2 sample solutions to be tested per Bar
2 to 3% TSP (trisodium phosphate) solution
questionnaires (a quantity equal to the total number of students taking the test per Bar)
1 group data sheet

PROCEDURE

1. Wash the bottles in the 2 to 3% TSP (trisodium phosphate) solution provided by your teacher and then thoroughly rinse with water to be sure the bottles are odor-free.
2. Drill a hole the size of the straws in the bottle cap. Insert a plastic straw into each of the holes just drilled into the caps (the straws should fit snugly into the hole).
3. Pour equal amounts of the sample solutions prepared by your teacher into the clean test bottles.
4. Fasten the straw/cap unit tightly on the bottle. Be sure that the end of the straw is well above the solution so that the sample will not be

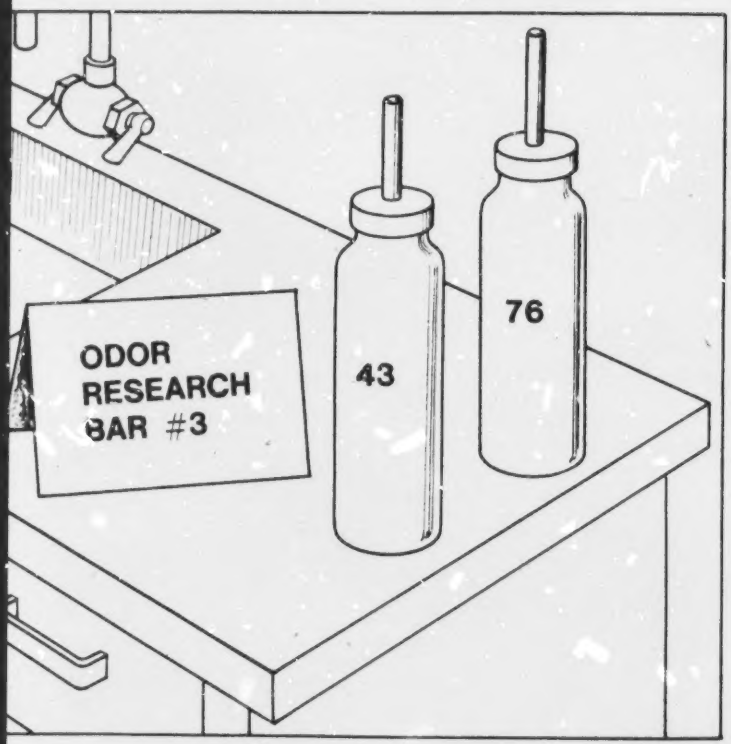


FIGURE 3

squirted when the bottle is squeezed (see Figure 2).

5. If the solutions can be seen through the bottle, cover the outside with opaque paper.
6. Your teacher will now code the bottles for you with randomly selected numbers.
7. After the bottles are placed on the Odor Research Bar (see Figure 3), each student judge should then gently squeeze the polyethylene bottle so that a puff of air enters his nose. He may take as long to sniff as he wishes.
8. After he has made a choice as to which sample he prefers, he should wait 30 to 60 seconds, then proceed to the next Bar.
9. After all samples have been tested, each team must clean up its area. Be sure the sample bottles are washed with TSP and rinsed thoroughly with water.
10. When the preference test has been run for the final time, fill out the Class Data Chart together.

Questions for Thought

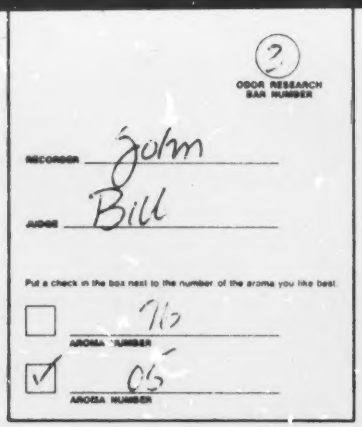
1. Which sample in each pair of samples was preferred? Why do you think it was preferred?
2. How do the boys compare with the girls in their preferences?
3. If you owned a grocery store, what might be some of the things you could learn from this Investigation?

Extending the Investigation

- Make a trip to your local grocery store to see if they stock more of the types of items your class preferred. Tell the store manager the results of your investigations.
- Determine your family's preferences.
- Determine the preferences of a lower-grade class, then of an upper-grade class and compare the results. Are there any major differences between age groups?

Suggested Reading

Odour Preferences, Moncrieff, R. W. Leonard Hill, London, 1966. This book is devoted to odor preferences, analyzing them according to age, sex, and temperament. Chapter 19 (pp. 271-96) is devoted to odors and foods. Good background reading.



◀ SAMPLE

Investigation 2

QUESTIONNAIRE FORM

ODOR RESEARCH BAR NUMBER

RECORDER _____

JUDGE _____

Put a check in the box next to the number of the aroma you like best.

☐ _____
AROMA NUMBER

☐ _____
AROMA NUMBER

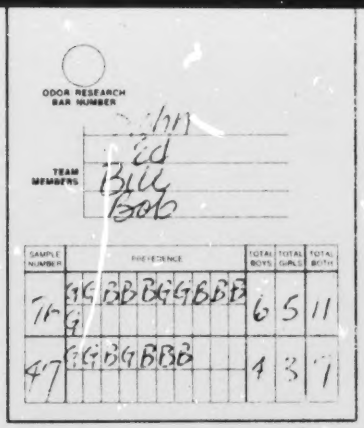
Investigation 2

TEAM DATA CHART

ODOR RESEARCH BAR NUMBER

TEAM MEMBERS

SAMPLE ➤



SAMPLE NUMBER	PREFERENCE										TOTAL BOYS	TOTAL GIRLS	TOTAL BOTH

Investigation 2

CLASS DATA CHART

◄ SAMPLE

ITEMS TESTED	Cheese Fish	Cracker Juice	Cinnamon Gum	Mustard Orange Juice	Chicken Apple Juice	Tomato Grape Juice	Pretzel Lemon Juice	Mushroom Banana
GIRL PREFERENCES	5	15	4	16	1	19	18	2
TOTAL GIRL JUDGMENTS	20		20		20		20	
PERCENT GIRL PREFERENCES	25%	75%	20%	80%	5%	95%	90%	10%
BOY PREFERENCES	20	10	25	5	3	27	25	5
TOTAL BOY JUDGMENTS	30		30		30		30	
PERCENT BOY PREFERENCES	67%	33%	83%	17%	10%	90%	83%	17%
COMBINED BOY AND GIRL PREFERENCES PER PRODUCT	25	25	29	21	4	46	43	7
GIRL AND BOY TOTAL JUDGMENTS	50		50		50		50	
PERCENT TOTAL PREFERENCES	50%	50%	58%	42%	8%	92%	86%	14%

ITEMS TESTED								
GIRL PREFERENCES								
TOTAL GIRL JUDGMENTS								
PERCENT GIRL PREFERENCES								
BOY PREFERENCES								
TOTAL BOY JUDGMENTS								
PERCENT BOY PREFERENCES								
COMBINED BOY AND GIRL PREFERENCES PER PRODUCT								
GIRL AND BOY TOTAL JUDGMENTS								
PERCENT TOTAL PREFERENCES								

INVESTIGATION 3
Olfactory Threshold Determination

Materials (per team)

2 narrow-mouth bottles (polyethylene) (250 ml) with lids
2 plastic straws
1 test solution, provided by the teacher
2 to 3% TSP solution
questionnaires (a quantity equal to the total number of students taking the test)
1 team data sheet
1 class data sheet per team member
1 graph per team member

PROCEDURE

You will use the same kind of bottles and Odor Research Bar as you did in Investigation 2. If necessary, refer to Figures 2 and 3 in that Investigation.

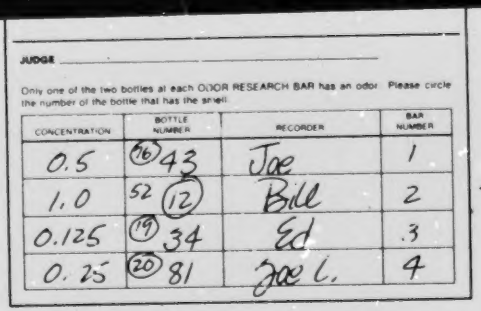
1. Wash the bottles with the 2 to 3% TSP solution provided by your teacher, then thoroughly rinse them with water.
2. Place the sample solution prepared by your teacher in one of your team's two bottles. Now put an equal amount of tap water in the other bottle. Your teacher will code the bottles for you.
3. Place the cap with the straw on the bottle. Be sure the end of the straw is well above the solution.
4. Begin testing now. Do the testing the same way you did in Investigation 2.
5. When you have finished the tests, clean your team's research area. At the same time, go over the data you have collected to make sure it is correct.
6. When you have completed the final day of testing, fill out the data charts and plot your graph together with the other Odor Research Bars.

Questions for Thought

1. What is the class olfactory threshold for the substance tested?
2. If a perfume manufacturer allowed an aroma to become too strong (well above the olfactory threshold of his customers), what might be the reaction of the people who used the product? What if the olfactory threshold was well below that of his customers?
3. If a gas company put an odorous indicator in a gas heating system, but in an amount below a community's olfactory threshold, what do you think might happen? How could this situation be corrected?

Extending the Investigation

- **Determine a lower grade's threshold for the substance you tested, then determine your parents' and teachers' threshold for the same substance. Compare them. Who has the higher threshold? Who will be most able to detect the presence of the substance in lowest quantity?**
- **Is there a store in your area that uses this substance in the preparation of its products? Do you think the amount of substance is above, below, or just at the right olfactory threshold for its customers? Do you think this information might be helpful to the store manager?**



JUDGE _____

Only one of the two bottles at each ODOR RESEARCH BAR has an odor. Please circle the number of the bottle that has the smell.

CONCENTRATION	BOTTLE NUMBER	RECORDER	BAR NUMBER
0.5	(16) 43	Joe	1
1.0	52 (12)	Bill	2
0.125	(19) 34	Ed	.3
0.25	(20) 81	Joe L.	4

◀SAMPLE

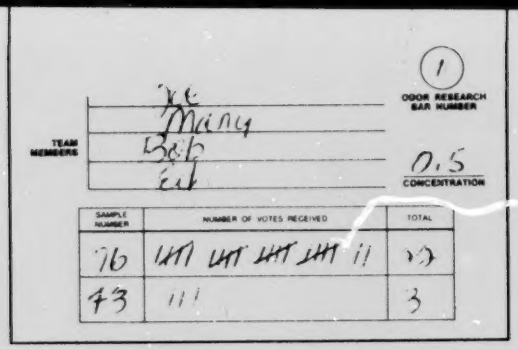
Investigation 3

QUESTIONNAIRE CHART

JUDGE _____

Only one of the two bottles at each ODOR RESEARCH BAR has an odor. Please circle the number of the bottle that has the smell.

CONCENTRATION	BOTTLE NUMBER	RECORDER	BAR NUMBER



Investigation 3

TEAM DATA CHART

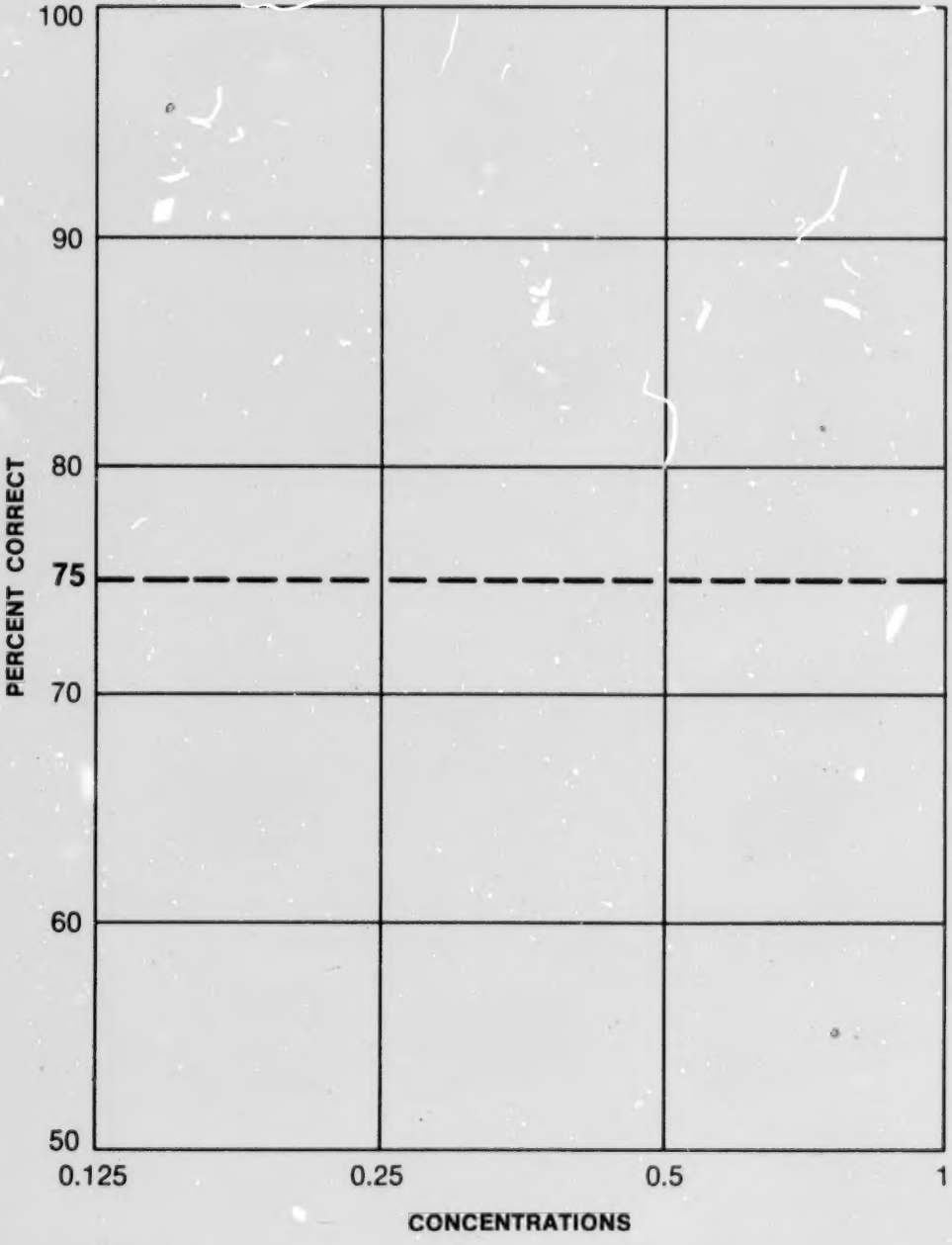
ODOR RESEARCH BAR NUMBER

CONCENTRATION

TEAM MEMBERS

SAMPLE NUMBER	NUMBER OF VOTES RECEIVED	TOTAL

CLASS GRAPH


100
90
80
75
70
60
50
PERCENT CORRECT
0.125
0.25
0.5
1
CONCENTRATIONS

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